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Coffin et al.

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(54) **CARTRIDGE PICKER ASSEMBLY**

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Related U.S. Application Data

(62) Division of application No. 09/603,156, filed on Jun. 23, 2000, now Pat. No. 6,301,072, which is a continuation of application No. 09/237,516, filed on Jan. 26, 1999, now Pat. No. 6,157,513.

(51) **Int. Cl.**[7] **G11B 15/68**; G11B 17/22

(52) **U.S. Cl.** **360/92**; 369/30.45

(58) **Field of Search** 360/92; 414/280, 414/751, 932, 751.1; 369/30.45, 30.43

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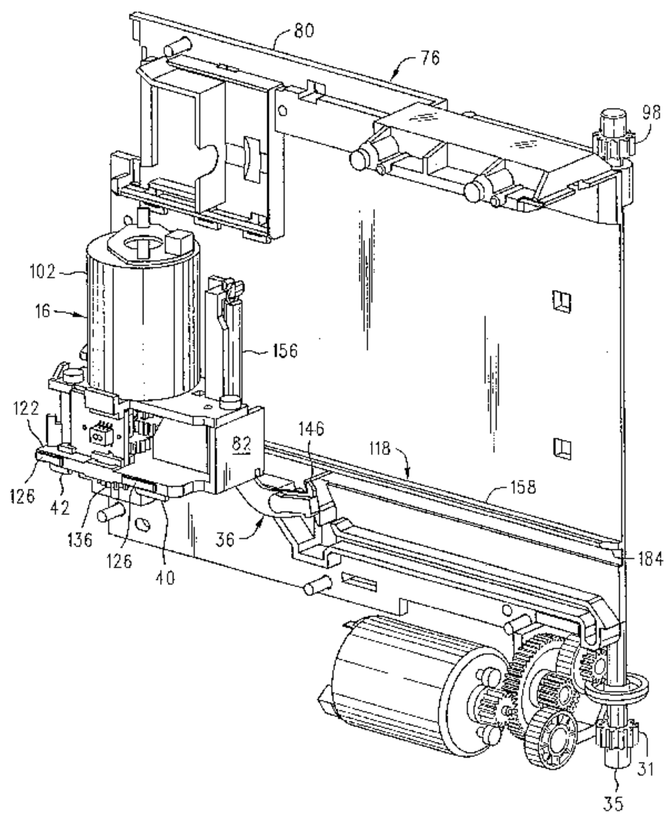
Primary Examiner—William Klimowicz

(57) **ABSTRACT**

A cartridge picker assembly may include a frame having a first side wall and a second side wall positioned in spaced-apart relation and a cartridge access end. A lateral guide surface being substantially parallel to a lateral plane is associated with the first side wall of the frame. A thumb assembly is slidably mounted to the first and second side walls of the frame so that the thumb assembly is capable of moving toward and away from the cartridge access end of the frame. A guide member flaunted to the thumb assembly engages the lateral guide surface on the first side wall of the frame so that lateral motion of the thumb assembly is controlled as the thumb assembly moves toward and away from the cartridge access end of the frame.

1 Claim, 9 Drawing Sheets



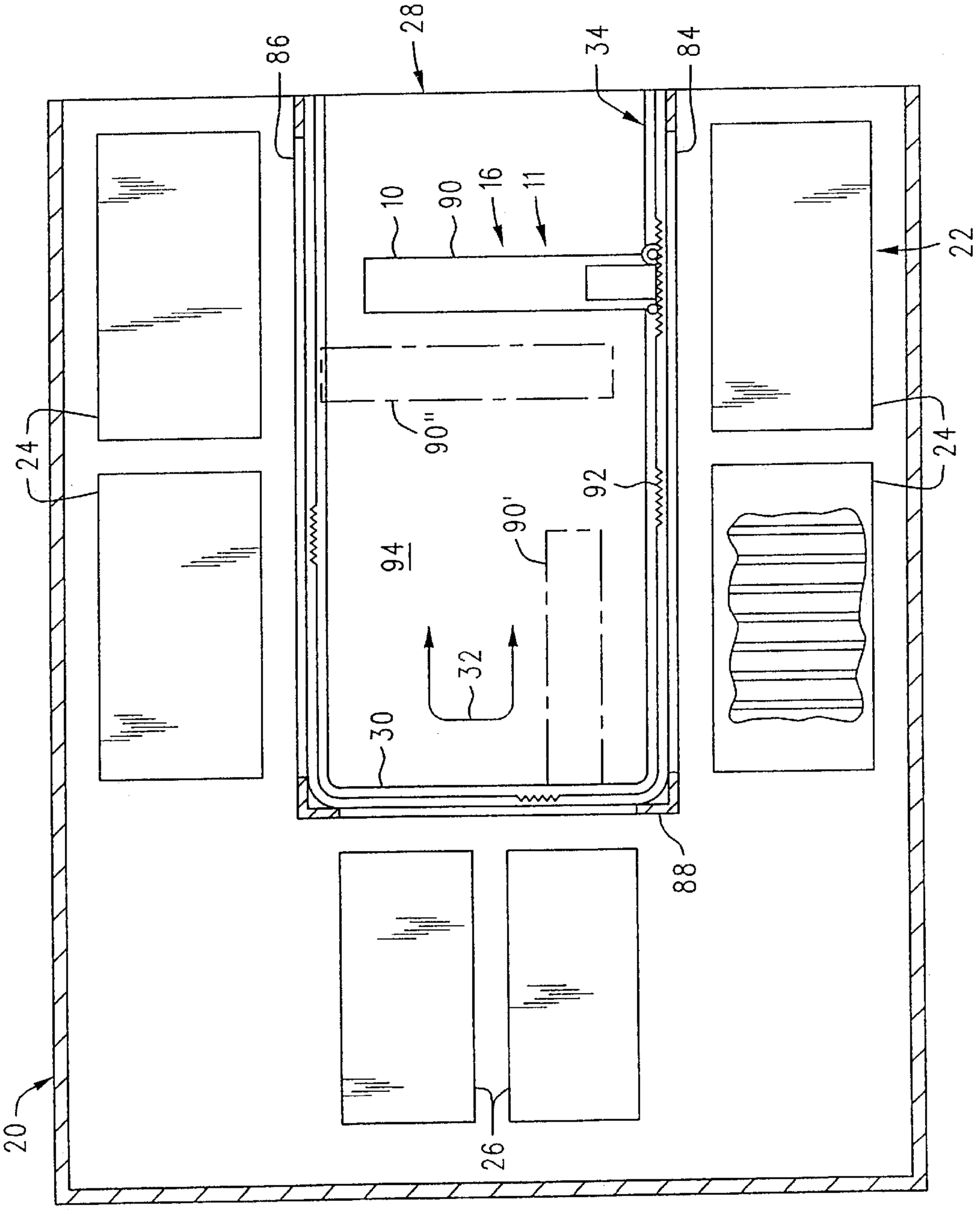


FIG. 1

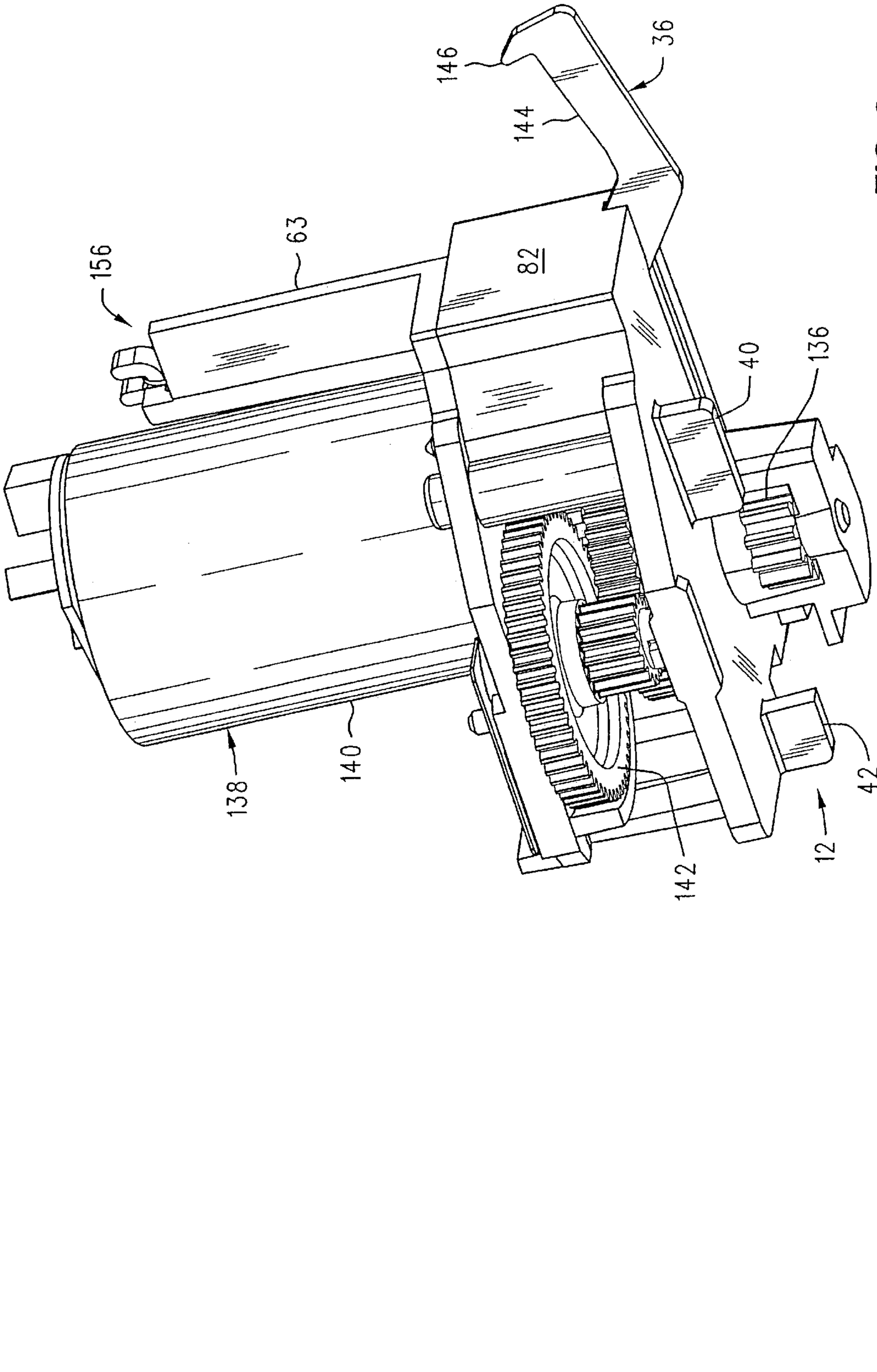


FIG. 2

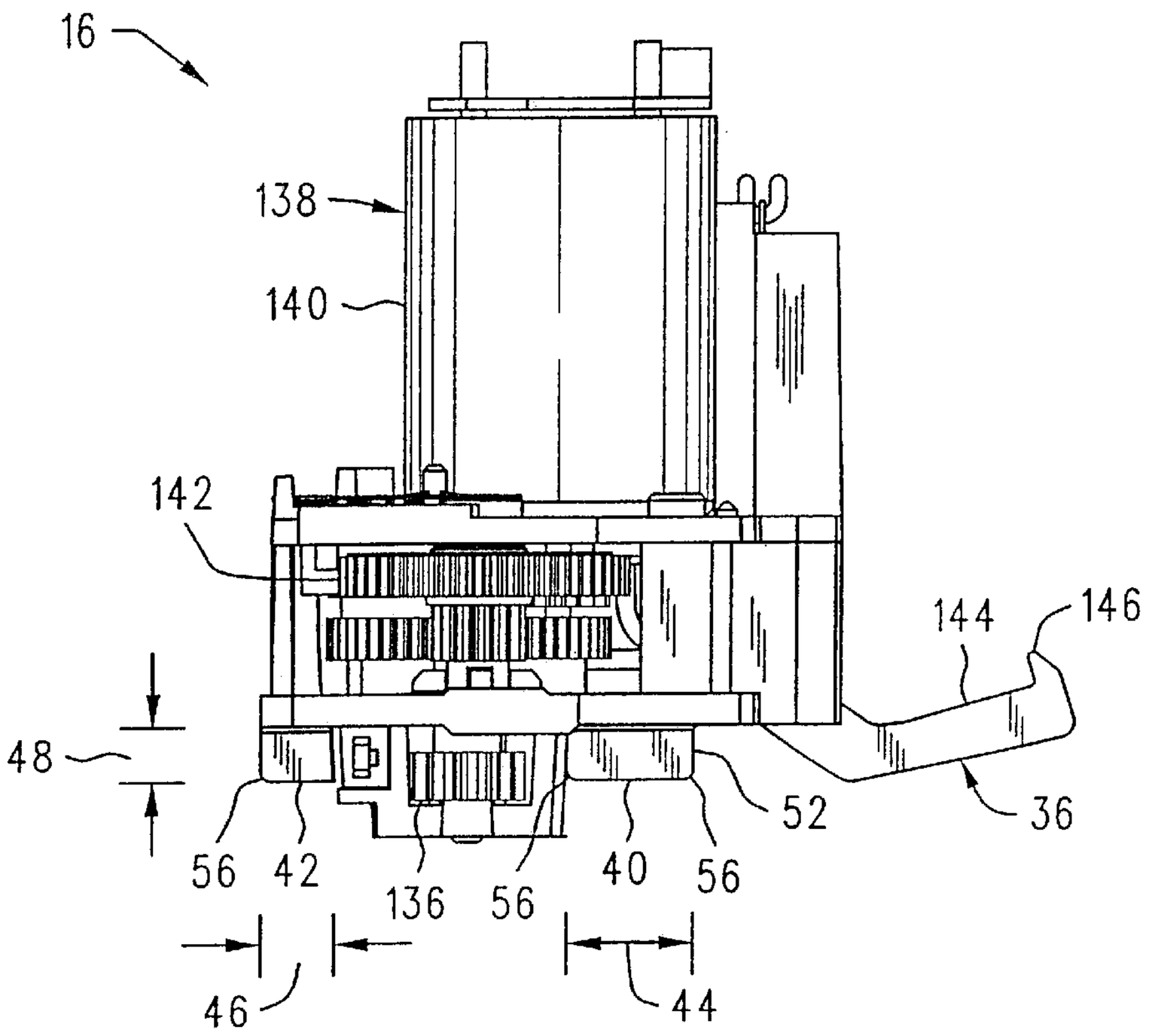

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FIG. 3

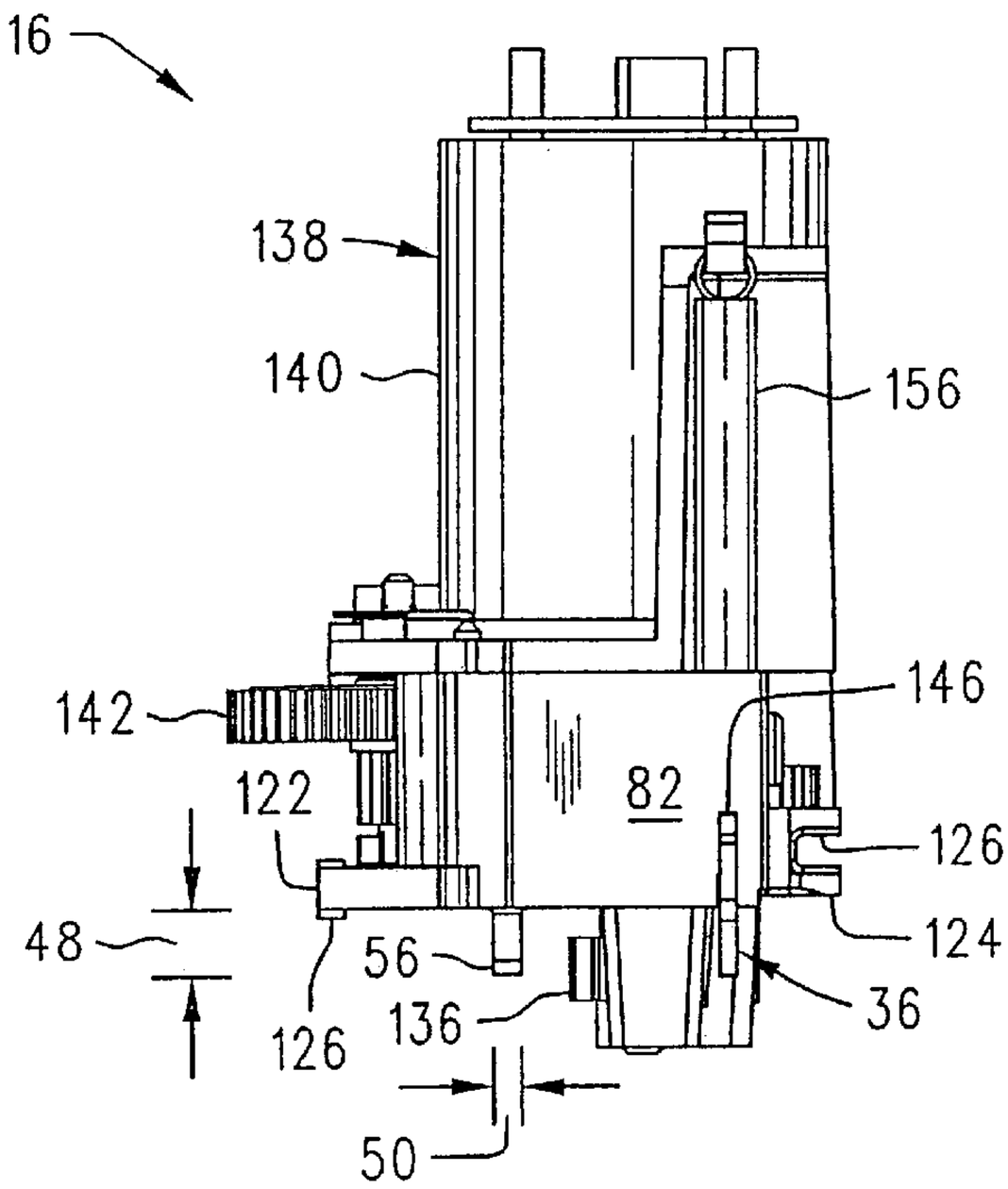
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FIG. 4

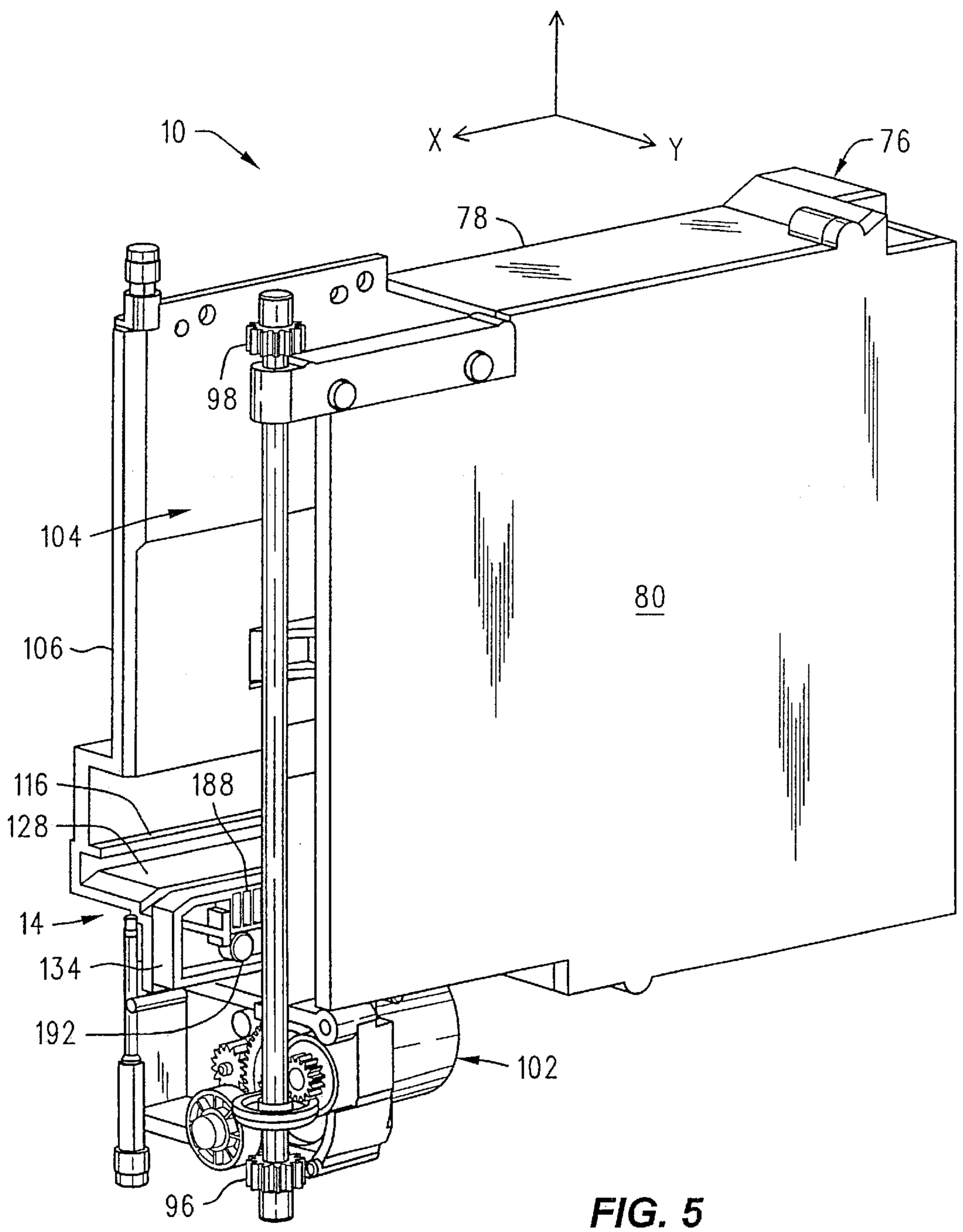

FIG. 5

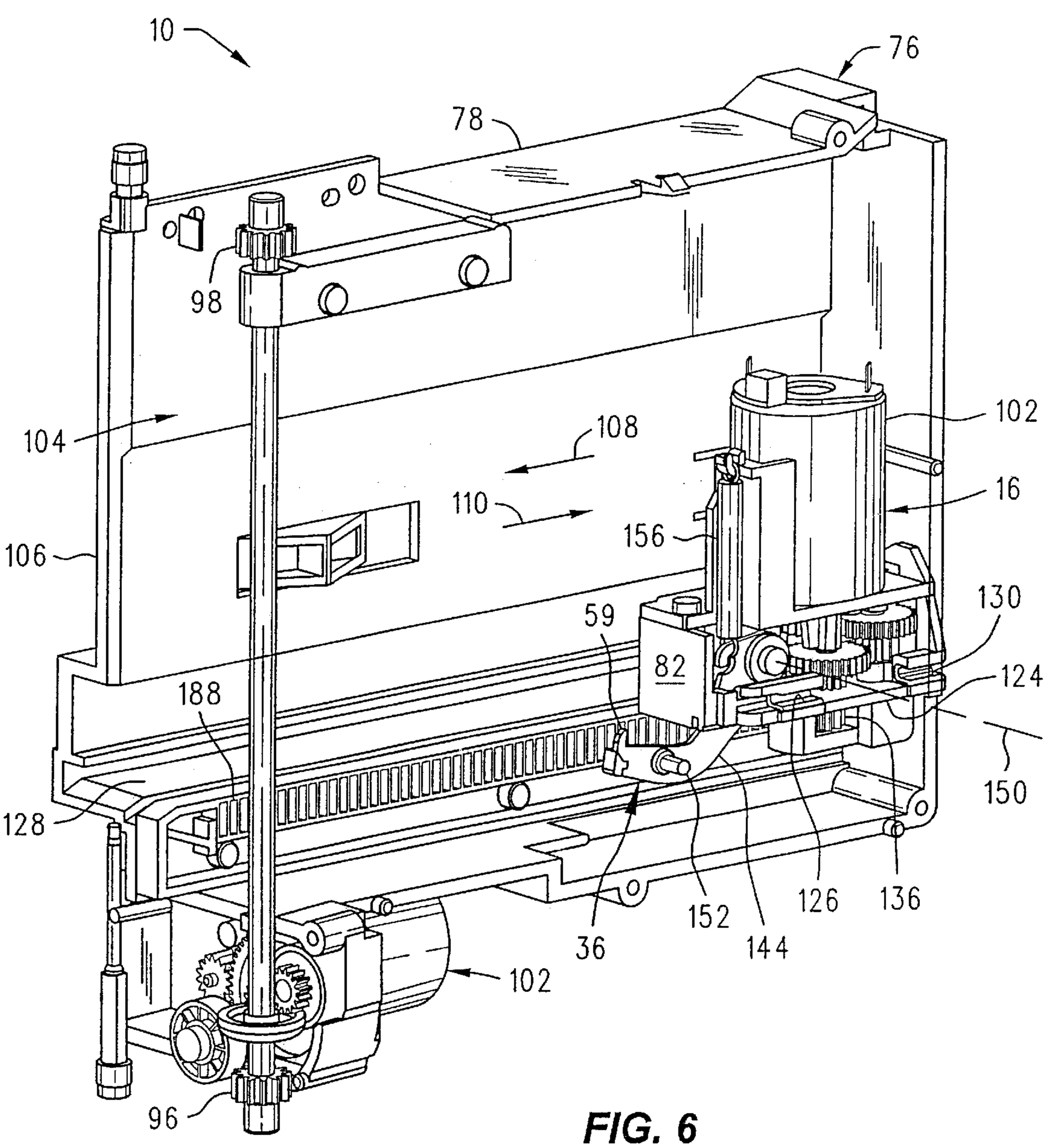
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FIG. 6

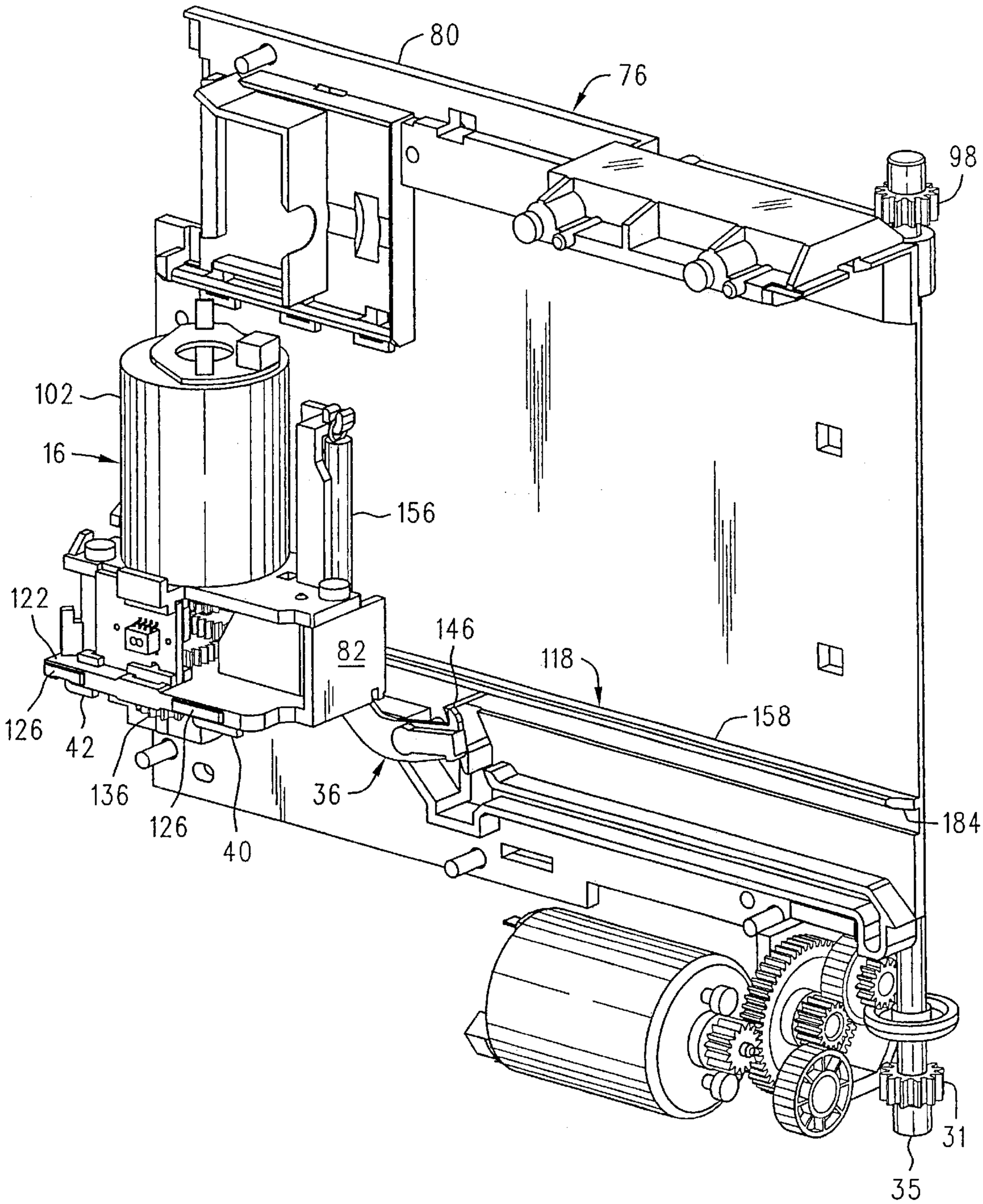
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FIG. 7

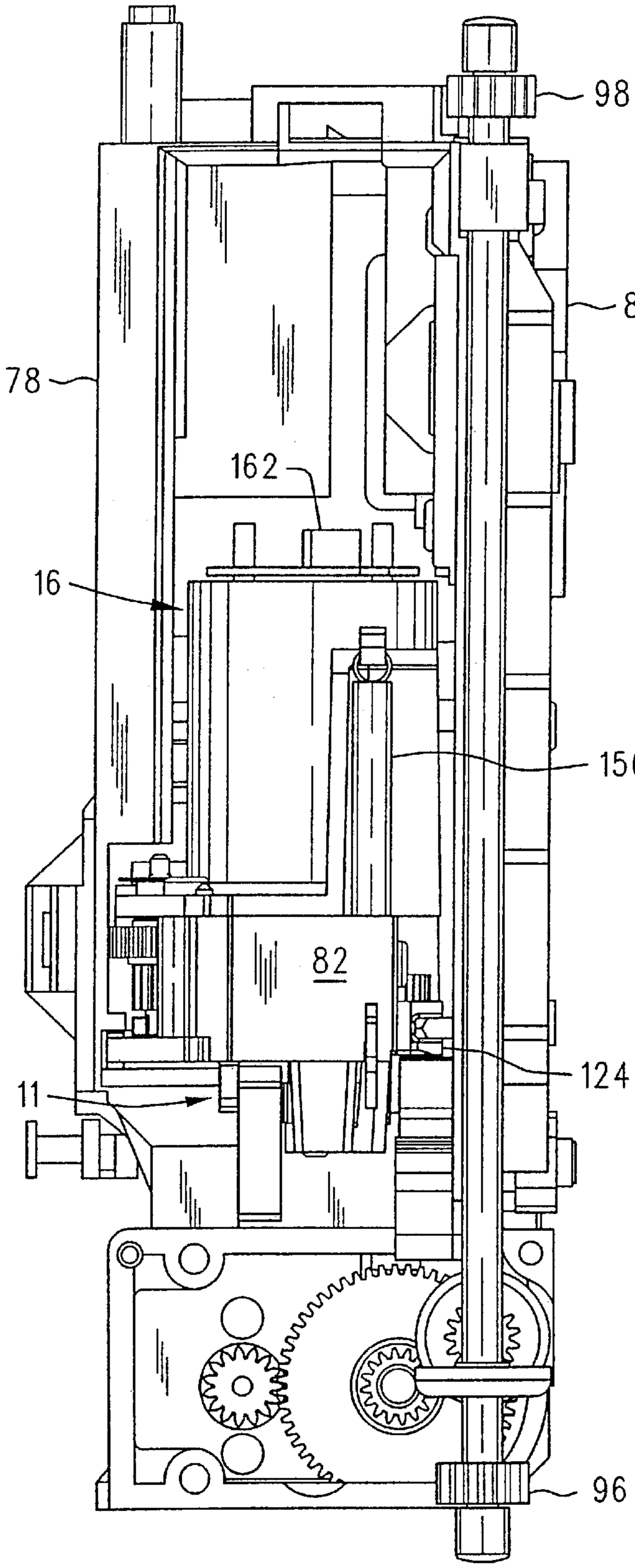

FIG. 8

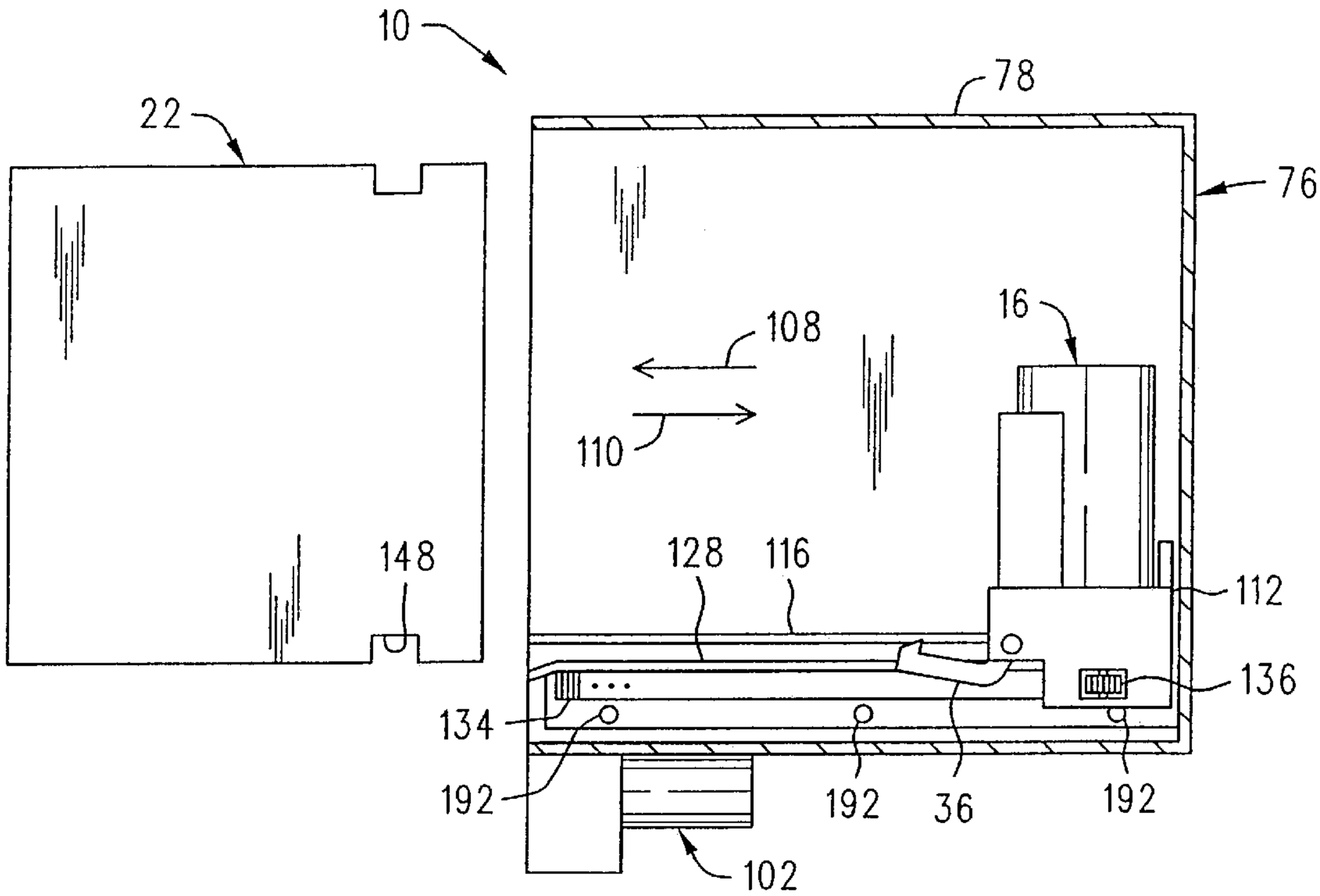
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FIG. 9A

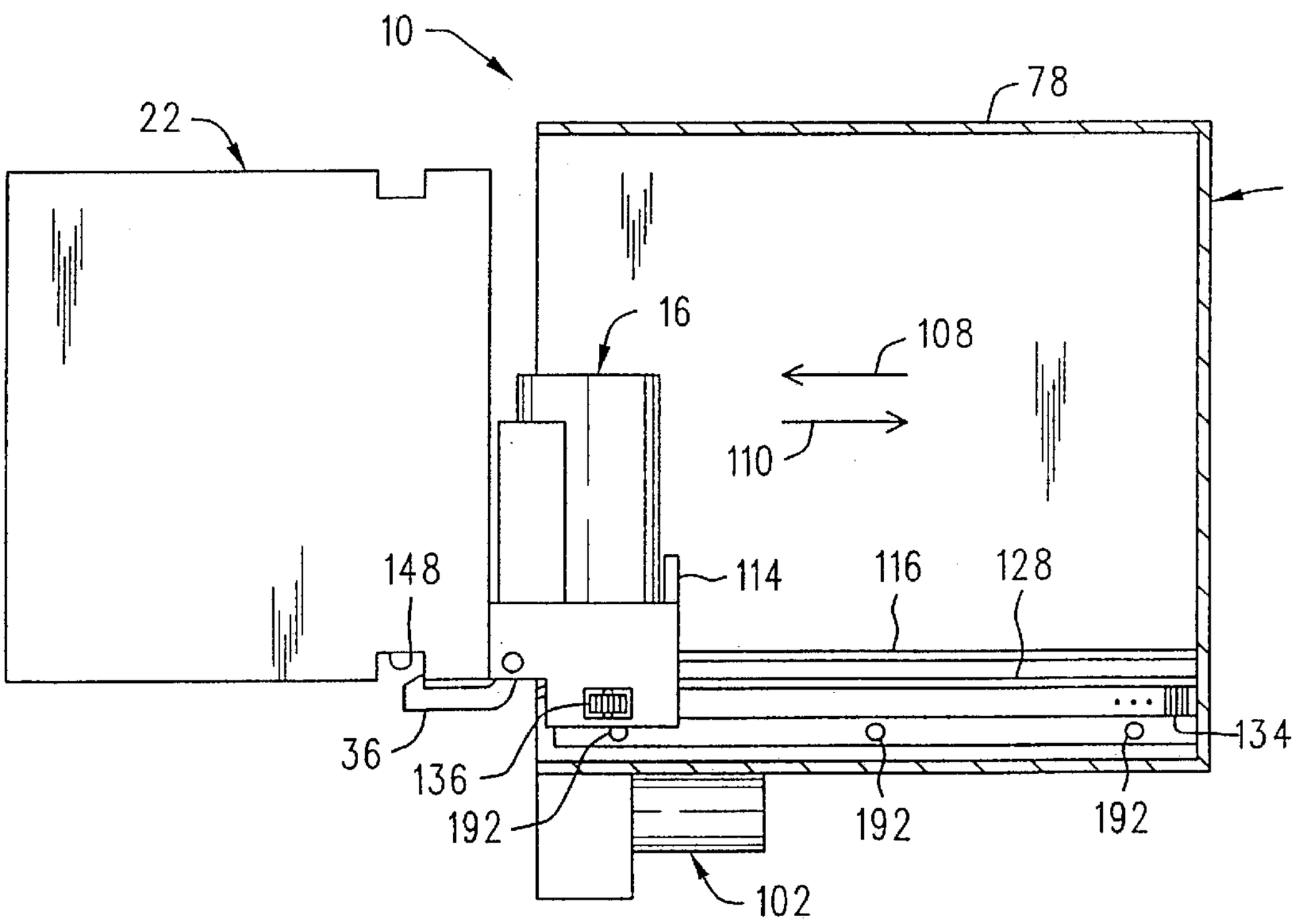
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FIG. 9B

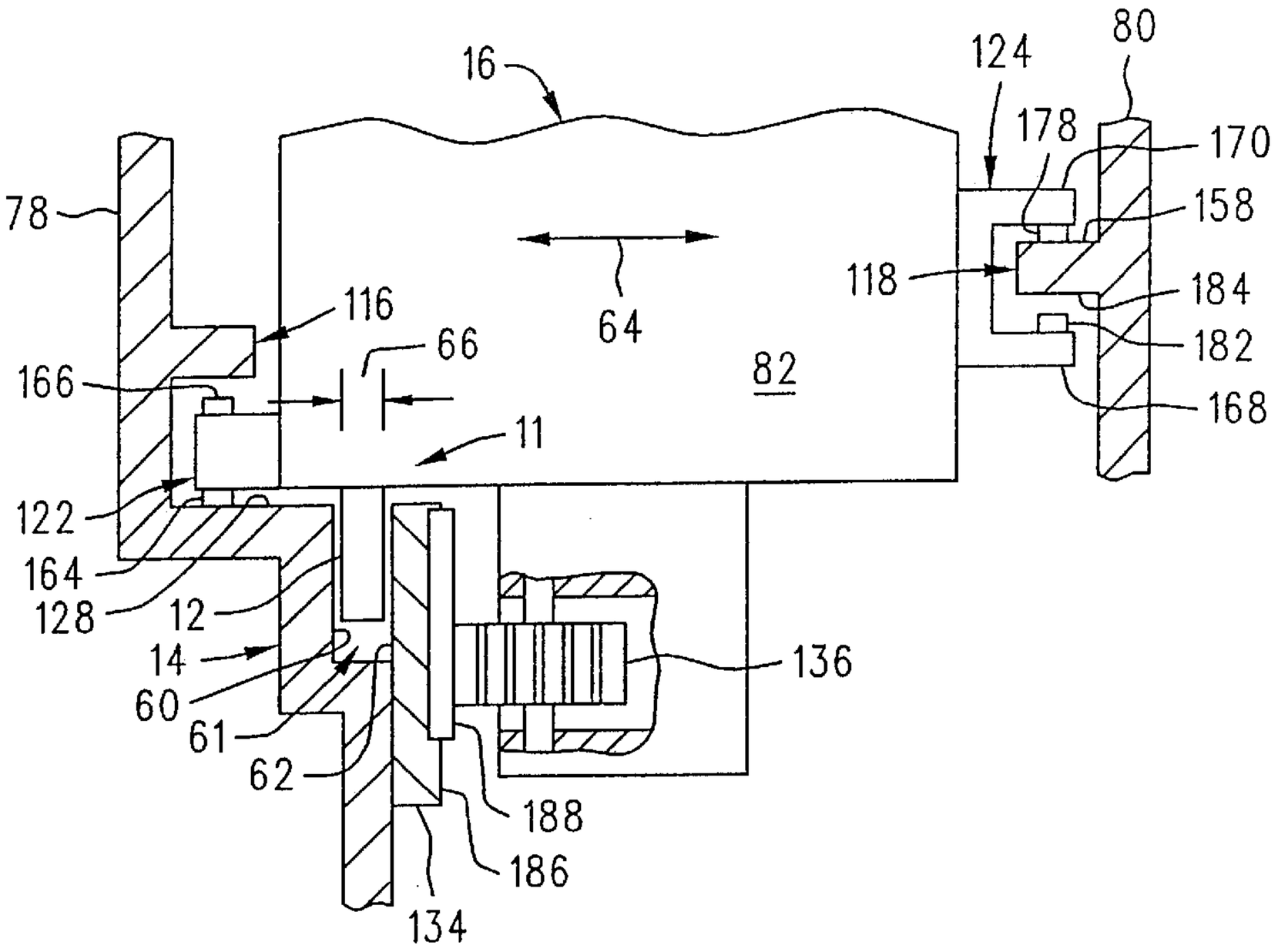

FIG. 10

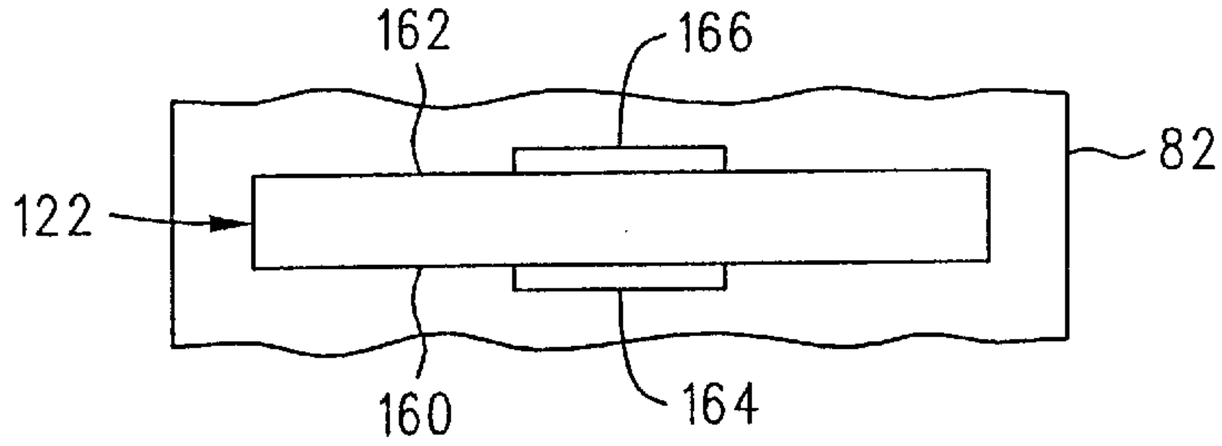

FIG. 11

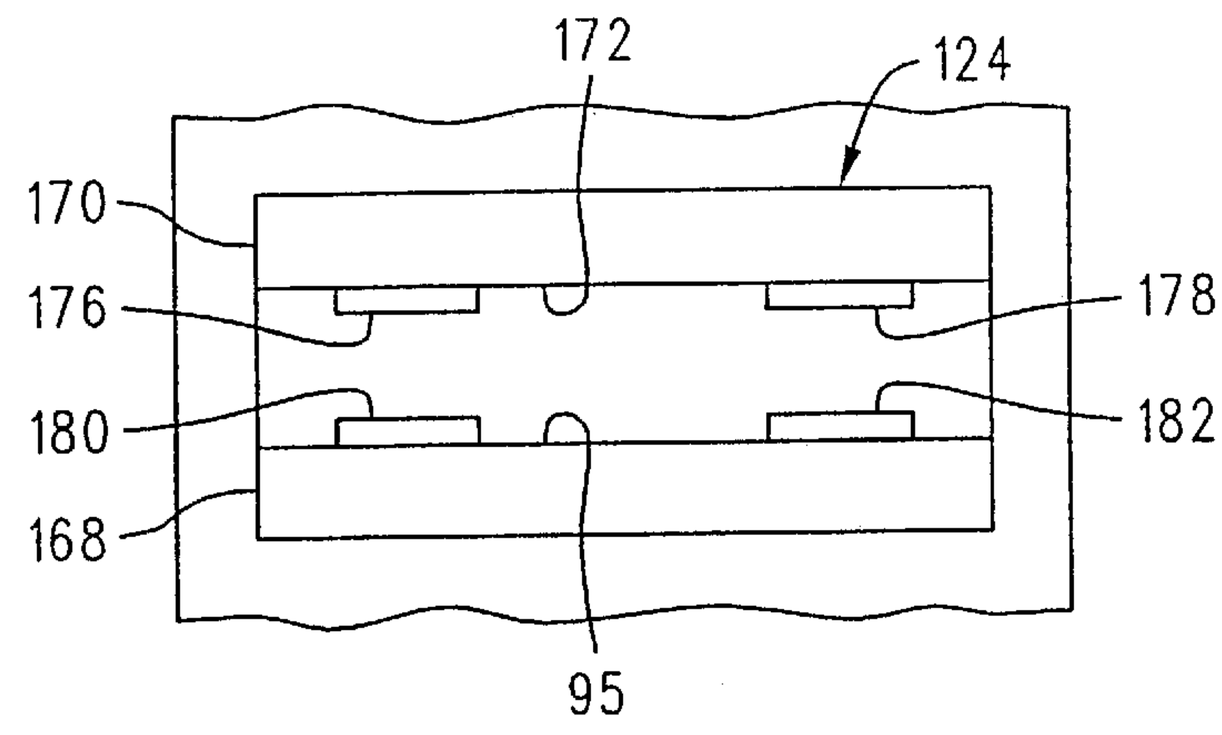

FIG. 12

CARTRIDGE PICKER ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

This is a divisional of copending application Ser. No. 09/603,156 filed on Jun. 23, 2000, now U.S. Pat. No. 6,301,072, which is a continuation of copending application Ser. No. 09/237,516, filed on Jan. 26, 1999, now U.S. Pat. No. 6,157,513, both of which are incorporated herein by reference for all that they disclose.

FIELD OF INVENTION

This invention relates generally to data storage systems for handling and storing data cartridges, such as optical disk or magnetic tape cartridges, and more specifically to cartridge access devices for engaging and retrieving the data cartridges stored in data storage systems.

BACKGROUND

Many different types of data storage systems exist and are being used to store data cartridges at known locations and to retrieve desired data cartridges so that data may be written to or read from the data cartridges. Such data storage systems are often referred to as "juke box" data storage systems, particularly if they can accommodate a large number of individual data cartridges.

A typical juke box data storage system may include one or more different types of cartridge receiving devices for holding the various data cartridges. For example, one type of cartridge receiving device may comprise a cartridge storage rack or "magazine" while another type of cartridge receiving device may comprise a cartridge read/write device. The cartridge storage racks or magazines serve to provide storage locations for the data cartridges and are often arranged so that they form one or more vertical stacks, although other configurations are possible. The cartridge read/write device may be located at any convenient location within the data storage system.

The data storage system may also be provided with a moveable cartridge picker assembly or "picker" for transporting the data cartridges between the various cartridge receiving devices, e.g., between the cartridge storage racks and the cartridge read/write devices. A typical cartridge picker assembly or picker may also be provided with a cartridge plunge mechanism or "thumb" assembly for engaging the various data cartridges contained in the cartridge receiving devices and for drawing them into the picker. A picker positioning system associated with the cartridge picker assembly may be used to move the cartridge picker assembly along the various cartridge receiving devices.

Data storage systems of the type described above are usually connected to a host computer system which may be used to access or store data on the data cartridges. For example, if the host computer system issues a request for data contained on a particular data cartridge, a control system associated with the data storage system will actuate the picker positioning system to move the picker assembly along the cartridge storage racks until the picker assembly is positioned adjacent the desired data cartridge. The cartridge plunge mechanism or "thumb" assembly associated with the picker assembly may then remove the data cartridge from the cartridge storage rack and draw it into the picker assembly. The picker positioning system may then be actuated to move the picker assembly to the appropriate cartridge read/write device. Once properly positioned adjacent the cartridge read/write device, the thumb assembly may insert the selected data cartridge into the cartridge read/write device so that the host computer may thereafter read data from or write data to the data cartridge. After the read/write operation is complete, the thumb assembly may be actuated to remove the data cartridge from the cartridge read/write device. The picker assembly may thereafter return the data cartridge to the appropriate location in the cartridge storage rack.

A typical cartridge plunge mechanism or "thumb" assembly is usually slidably mounted to the picker and is provided with a thumb actuator system to move the thumb assembly toward and away from a cartridge access end of the picker. For example, if it is desired to retrieve a data cartridge from a cartridge receiving device, the thumb actuator system moves the thumb assembly toward the cartridge access end of the picker so that the thumb assembly can engage or "grab" the data cartridge. Thereafter, the thumb actuator system may retract the thumb assembly and engaged data cartridge into the picker. If it is desired to load the data cartridge into the cartridge receiving device, then the thumb actuator moves the thumb assembly and data cartridge toward the cartridge access end of the picker, and inserts the data cartridge into the cartridge receiving device.

In order to reliably engage a cartridge, the thumb assembly must be positioned adjacent the cartridge within precise tolerances. As the thumb assembly is moved toward or away from the cartridge access end of the picker, lateral and vertical movement is limited by the thumb actuator system or by guide rails on each side of the thumb assembly. If the thumb assembly is not correctly positioned adjacent the cartridge, the thumb assembly will be unable to properly engage or disengage the cartridge.

Currently known mounting systems are not without their problems. In one currently known mounting system, the thumb assembly is mounted to the cartridge picker assembly on a lead screw which drives and positions the thumb assembly. A lead screw is rotatably mounted to the cartridge picker assembly and runs the length of the picker assembly, passing through the thumb assembly and engaging with a gear or teeth on the thumb assembly. Thus, when the lead screw rotates, the thumb assembly is moved toward or away from the cartridge access end of the picker. The lead screw drive system provides generally good positioning accuracy once aligned, but requires the use of expensive machined elements and is difficult to assemble and align. Furthermore, the teeth and threads tend to wear down over time as they turn against each other, reducing the positioning accuracy. In addition, the minimum gaps required for moving parts may exceed the tolerances required for lateral positioning. For example, if the thumb actuator system is a lead-screw drive system, gaps are required between the lead-screw and the teeth in the thumb assembly to prevent binding. These gaps required for the operation of the drive system may allow lateral movement which exceeds the tolerances required for lateral positioning. A lead-screw drive system may also require a secondary guide member, such as a precision-machined rod, which is relatively expensive and may pose assembly and alignment problems.

In addition, positioning errors may accumulate within the picker with each additional part in the guide system. For example, for a lead-screw drive system, the position of the thumb assembly is affected by multiple parts. First, the gap between the lead-screw and the threads in the thumb assembly has a given tolerance. The lead-screw may be held in place by a set of ball bearings which also have a given

tolerance. The ball bearings may be held in a casing having a tolerance, which in turn may be attached to the side of the picker which also has a tolerance. Each tolerance adds up, forming a tolerance stack, making it more difficult to maintain the lateral position of the thumb assembly as the tolerance stack deepens.

In another currently known mounting system, the thumb assembly is mounted in the picker with guide rails on each side of the picker. Support members extend from the sides of the thumb assembly to engage in the picker guide rails to guide the thumb assembly as it moves toward and away from the cartridge access end of the picker. A guide rail mounting system provides a less-expensive alternative to a lead-screw, and may eliminate some of the expensive machined parts and may facilitate assembly and alignment. However, a guide rail mounting system is subject to a high tolerance stack and large, molded parts which are easily warped. The guide rails are typically molded into the plastic side panels of the picker, which can warp during manufacture and assembly, and which can flex during operation.

In addition, the drive system of the picker assembly typically mounts to one side, correctly positioning that side of the picker assembly adjacent a cartridge or a cartridge receiving device. However, guide rails are located on both sides of the picker, and there may be several elements between the two sides of the picker. Therefore, the tolerance stack for the guide rail mounting system includes the tolerances for all elements between the correctly positioned first side and the guide rail on the second side. In other words, correct positioning of the thumb assembly in a picker having a guide rail mounting depends upon correct sizing and placement of multiple elements in the picker. The large tolerance stack and the dependence upon easily warped or flexed components leads to an undesirably high rate of incorrect positioning.

Consequently, a need exists for an improved thumb assembly mounting and guide system to control lateral motion. In particular, a need exists for a guide system having a reduced tolerance stack and having more easily controlled tolerances, using relatively inexpensive components.

SUMMARY OF THE INVENTION

A cartridge picker assembly may include a frame having a first side wall and a second side wall positioned in spaced-apart relation. A lateral guide surface positioned on the first side wall of the frame is substantially parallel to a lateral plane. A thumb assembly is slidably mounted to the first and second side walls of the frame so that the thumb assembly is capable of moving toward and away from the cartridge access end of the frame. A guide member mounted to the thumb assembly engages the lateral guide surface on the first side wall of the frame so that lateral motion of the thumb assembly is controlled as the thumb assembly moves toward and away from the cartridge access end of the frame.

BRIEF DESCRIPTION OF THE DRAWING

Illustrative and presently preferred embodiments of the invention are shown in the accompanying drawing in which:

FIG. **1** is a plan view of a media access device and cartridge picker assembly according to the present invention as it may be used in a data storage system to access and transport data cartridges contained within the data storage system;

FIG. **2** is a side view of a thumb assembly showing the guide member;

FIG. **3** is a side view of the thumb assembly of FIG. **2**;

FIG. **4** is a front view of the thumb assembly of FIG. **2**;

FIG. **5** is a perspective view of the cartridge picker assembly;

FIG. **6** is a perspective view of the left side of the cartridge picker assembly showing the thumb assembly;

FIG. **7** is a perspective view of the right side of the cartridge picker assembly showing the thumb assembly;

FIG. **8** is an end view in elevation showing the engagement of the thumb and guide rail assemblies;

FIGS. **9**(*a–b*) are simplified sectional views in elevation showing the thumb assembly in the retracted and extended positions;

FIG. **10** is an enlarged cross-section view in elevation of the thumb and guide rail assembly more clearly showing the engagement of the guide member with the lateral guide surface;

FIG. **11** is an enlarged side view of the first flange member of the thumb assembly; and

FIG. **12** is an enlarged side view of the second, C-shaped flange member of the thumb assembly.

DETAILED DESCRIPTION OF THE INVENTION

A cartridge picker assembly or "picker" **10** having an improved thumb referencing and guide system **11** is shown in FIG. **1** as it could be used in a "juke box" data storage system **20** to transfer data cartridges **22** between one or more cartridge receiving devices, such as one or more cartridge storage racks or magazines **24** and one or more cartridge read/write devices **26**.

The improved thumb referencing and guide system **11** is used to support and guide a cartridge plunge mechanism or "thumb assembly" **16** as the same is moved back and forth within the picker assembly **10**. The improved thumb referencing and guide system **11** comprises a guide member **12** provided on the cartridge plunge mechanism **16** and a lateral guide surface **14** on the cartridge picker assembly **10**. The improved thumb referencing and guide system **11** thereby provides control of the lateral position of the cartridge plunge mechanism **16** within the cartridge picker assembly **10**. As the cartridge plunge mechanism **16** slides within the cartridge picker assembly **10** to grasp or release a data cartridge **22**, the guide member **12** slides against the lateral guide surface **14** to control lateral position. The guide member **12** and the lateral guide surface **14** thereby substantially reduce the likelihood that the cartridge plunge mechanism **16** will become misaligned and fail to grasp a data cartridge **22**.

The juke box data storage system **20** in which the improved thumb referencing and guide system **11** may be used is best seen in FIG. **1** and may comprise a generally rectangularly shaped frame or chassis assembly **28** around which are arranged a plurality of cartridge receiving devices, such as the cartridge storage racks or magazines **24** and cartridge read/write devices **26**. In the embodiment shown and described herein, the various cartridge receiving devices (e.g., the cartridge storage racks or magazines **24** and the cartridge read/write devices **26**) are positioned so that they define a generally U-shaped configuration, as best seen in FIG. **1**. However, other configurations are possible. Alternatively, and as will be described in greater detail below, the cartridge picker assembly or picker **10** according to the present invention may be used in any of a wide range of other types of data storage systems.

The cartridge picker assembly **10** may be mounted to a U-shaped guide track **30** provided on the frame or chassis assembly **28**. The U-shaped guide track **30** guides the cartridge picker assembly **10** along a generally U-shaped path **32**, thereby allowing the cartridge picker assembly or picker **10** to access all of the cartridges **22** stored in the various cartridge receiving devices (e.g., **24**, **26**). A picker positioning system **34** operatively associated with the cartridge picker assembly **10** may be used to move the cartridge picker assembly **10** to various positions along the U-shaped guide track **30**.

Referring now primarily to FIGS. **2**, **4**, **6**, and **7**, the cartridge picker assembly **10** may be provided with a cartridge plunge mechanism or "thumb" assembly **16** for removing and replacing the data cartridges **22** contained within the various cartridge receiving devices. In one preferred embodiment, the thumb assembly **16** is moveably mounted within the cartridge picker assembly **10** so that the thumb assembly **16** may be moved between a retracted position **112** (shown in FIG. **9**A) and an extended position **114** (shown in FIG. **9**B). That is, the thumb assembly **16** may be extended and retracted within the cartridge picker assembly **10** in the directions indicated by arrows **108** and **110**, respectively. The thumb assembly **16** may be provided with a finger assembly **36** to allow the thumb assembly **16** to engage and disengage a data cartridge **22**, as will be described in greater detail below.

Referring now primarily to FIGS. **3**, **4**, **6**, and **10**, the lateral position of the thumb assembly **16** within the cartridge picker assembly **10** may be controlled by an improved thumb referencing and guide system **11** (FIG. **10**), comprising the guide member **12** and the lateral guide surface **14**. The guide member **12** may comprise a plurality of guide ribs that extend from the thumb assembly **16**. In one preferred embodiment, the guide member **12** comprises a front guide rib **40** and a rear guide rib **42**. The front and rear guide ribs **40** and **42** have a height **48** and a width **50** enabling them to engage the lateral guide surface **14**. As seen in FIGS. **6** and **10**, the lateral guide surface **14** may comprise a first contact surface **60** and a second contact surface **62**, placed in parallel spaced-apart relation to form a channel **61** (see FIG. **10**). The guide member **12** engages with the lateral guide surface **14**, as seen in FIG. **8**, to prevent side-to-side, or lateral movement (indicated by arrows **64**) of the thumb assembly.

In one preferred embodiment, the first contact surface **60** is substantially parallel to a lateral plane formed by an X axis and a Z axis (FIG. **5**), and may comprise a first side wall **78** of the cartridge picker assembly frame **76**. The second contact surface **62** may comprise an elongate wall attached to the first side wall **78** of the cartridge picker assembly frame **76**. Hence, the lateral guide surface **14** controls the lateral position of the thumb assembly **16** based upon the first side wall **78** rather than both the first side wall **78** and a second side wall **80** of the cartridge picker assembly frame **76**. The resulting tolerance stack is thereby minimized by removing a dependence upon the second side wall **80** and various other components between the first and second side walls **78** and **80**.

This is a substantial advantage over using the guide rails (e.g., **116** and **118**) at each side of the thumb assembly **16** for lateral positioning. One benefit of using only the first side wall **78** to control lateral position of the thumb assembly **16** is that the number of elements in the cartridge picker assembly **10** included in the tolerance stack for lateral position is minimized. A second benefit is that the elements remaining in the tolerance stack are more easily controlled. For example, large molded plastic elements such as the second side wall **80** of the cartridge picker assembly **76** and the thumb assembly frame **82**, which are easily warped during the molding process, are kept out of the tolerance stack.

Having briefly described the improved thumb referencing and guide system **11** including the guide member **12** and the lateral guide surface **14**, as well as some of its more significant features and advantages, the various embodiments of the improved thumb referencing and guide system **11** according to the present invention will now be described in detail. However, before proceeding with the description, it should be noted that the improved thumb referencing and guide system **11** according to the present invention may be utilized in any of a wide range of cartridge engaging assemblies in any of a wide variety of data storage systems now known or that may be developed in the future. Accordingly, the present invention should not be regarded as limited to the particular data storage system **20** and cartridge picker assembly **10** shown and described herein.

With the foregoing considerations in mind, one embodiment of an improved thumb referencing and guide system **11** is shown and described herein as it may be used in a cartridge picker assembly **10**. The cartridge picker assembly **10** may, in turn, be used in a portion of a "juke box" data storage system **20**. In one preferred embodiment, the juke box data storage system **20** may comprise a data storage system of the type shown and described in U.S. patent application Ser. No. 09/045,134, filed Mar. 20, 1998, now U.S. Pat. No. 6,025,972, entitled "Multi-Plane Translating Cartridge Handling System," which is incorporated herein by reference for all that it discloses. Alternatively, the data storage system **20** may be of the type shown and described in U.S. Pat. No. 5,596,556, entitled "Linear Displacement and Support Apparatus for use in a Cartridge Handling System," which is also incorporated herein by reference for all that it discloses.

Referring now primarily to FIG. **1**, the data storage system **20** shown and described in U.S. patent application Ser. No. 09/045,134, now U.S. Pat. No. 6,025,972, referred to above may comprise a generally rectangularly shaped frame or chassis assembly **28** having a pair of opposed side portions **84** and **86** and an end portion **88** around which are positioned various cartridge receiving devices. More specifically, a pair of cartridge storage racks or magazines **24** may be positioned adjacent each opposed side portion **84** and **86** of the frame or chassis assembly **28**, whereas a pair of cartridge read/write devices **26** may be positioned adjacent the end portion **88** of the frame assembly **28**. Accordingly, the various cartridge receiving devices (e.g., the cartridge storage racks or magazines **24** and the cartridge read/write devices **26**) define a generally U-shaped configuration.

A picker positioning system **34** may be used to move the cartridge picker assembly **10** along the U-shaped guide track **30**. For example, in the embodiment shown and described herein, the picker positioning system **34** may move the cartridge picker assembly **10** between a first position **90** adjacent the first side portion **84** of the frame assembly **28**, a second position **90'** adjacent the end portion **88** of frame assembly **28**, and a third position **90"** adjacent the second side portion **86** of frame assembly **28**.

The picker positioning system **34** may comprise a rack and pinion drive system having a U-shaped gear rack **92** mounted to the lower plate **94** of frame assembly **28** at a position adjacent the U-shaped guide track **30**. The cartridge picker assembly **10** may be provided with a lower pinion

gear **96** (FIG. **5**) sized and positioned so that it will engage the lower U-shaped gear rack **92** provided on the lower plate **94**. Similarly, the cartridge picker assembly **10** may also be provided with an upper pinion gear **98** sized and positioned so that it will engage an upper U-shaped gear rack provided on an upper plate **100** (not shown). A drive pinion actuator system **102** mounted to the cartridge picker assembly **10** may be used to drive the lower and upper pinion gears **96** and **98**, thereby allowing the picker assembly **10** to be moved along the U-shaped path

The details of the cartridge picker assembly **10** that may be utilized in one preferred embodiment of the present invention are best seen in FIGS. **5–7**. Essentially, the cartridge picker assembly **10** may include a picker frame assembly **76** having a first side wall or member **78** and a second side wall or member **80**. The two side members **78** and **80** define an interior chamber or cavity **104** of sufficient size to receive a data cartridge **22**. The thumb assembly **16** is slidably mounted to the frame assembly **76** so that the thumb assembly **16** may be moved along an X axis toward and away from the cartridge access end **106** of frame assembly **76**, i.e., generally in the directions of arrows **108** and **110**, respectively. See FIG. **6**. More specifically, the thumb assembly **16** is slidably mounted to the frame assembly **76** so that the thumb assembly **16** may be moved between a retracted position **112** (illustrated in FIG. **9***a*) and an extended position **114** (illustrated in FIG. **9***b*).

The thumb assembly **16** may be mounted on first and second elongate guide rails **116** and **118** that are provided on the first and second sides **78** and **80** of the picker frame assembly **76**. See FIGS. **10**, **11**, and **12**. The first elongate guide rail **116** includes a first horizontal guide surface **128**, whereas the second elongate guide rail **118** includes a second horizontal guide surface **158**. In one preferred embodiment, the first and second horizontal guide surfaces **128** and **158** are non-coplanar, as best seen in FIG. **10**. Alternatively, the first and second horizontal guide surfaces **128** and **158** may be coplanar. In any event, the main body portion **82** of the thumb assembly **16** may include a first flange member **122** sized and positioned to engage the first horizontal guide surface **128** of first elongate guide rail **116**. The main body portion **82** of the thumb assembly **16** may also include a second or C-shaped flange member **124** adapted to engage the second horizontal guide surface **158** of the second elongate guide rail **118**.

Referring now primarily to FIGS. **10** and **11**, the first flange member **122** may comprise a generally rectangularly shaped member having a bottom surface **160** and a top surface **162**. A first or lower bearing member **164** is provided on the bottom surface **160** of first flange member **122** and contacts the first horizontal guide surface **128**, as best seen in FIG. **10**. The top surface **162** of flange member **122** may also be provided with an upper bearing member **166**. The upper bearing member **166** is positioned so that it may contact a horizontal capture rail **116**. However, upper bearing member **166** does not normally contact horizontal capture rail **116**.

The second flange member **124** may comprise a substantially C-shaped member and is best seen in FIGS. **10** and **12**. Essentially, the second flange member **124** comprises a lower horizontal member **168** and an upper horizontal member **170**. The bottom facing surface **172** of upper horizontal member **170** may be provided with a pair of bearing members **176** and **178** positioned in spaced-apart relation. The pair of bearing members **176** and **178** contact the second horizontal surface **158** on the second guide rail **118**, as best seen in FIG. **10**. The upper facing surface **174** of lower horizontal member **168** may be provided with a pair of bearing members **180** and **182** positioned so that they may contact the bottom surface **184** of the second guide rail **118**. The bearing members **180** and **182** provided on the lower horizontal member **168** do not normally contact the bottom surface **184** of the second guide rail **118**.

In accordance with the structural arrangement described above, the thumb assembly **16** is vertically supported on one side by the bearing member **164** that contacts the first horizontal surface **128**, and on the other side by the bearing members **176** and **178** that contact the second horizontal surface **158**. The three bearing members **164**, **176**, and **178** allow the thumb assembly **16** to be moved along a defined horizontal plane (not shown), even though the bearing members **164**, **176**, and **178** themselves may be non-coplanar.

The various components just described may be made from any of a wide range of materials, such as metals or plastics, suitable for the intended application. For example, in one preferred embodiment, the first and second side members **78** and **80** comprising the picker frame assembly **76** are molded from a polycarbonate plastic material. Accordingly, the various components and features contained therein, e.g., the guide rail **116**, horizontal guide surface **128**, along with the second guide rail **118**, may be provided as integral components of the respective side members **78** and **80**. Alternatively, the first and second side members **78** and **80** comprising the picker frame assembly **76** may be made from other materials, in which case the various components and features of the side members **78** and **80** may comprise integral components or separate elements, depending on the particular design and material to be utilized.

The main body portion **82** of the thumb assembly **16** may also be made from any of a wide range of materials suitable for the intended application. For example, in the embodiment shown and described herein, the main body portion **82** of thumb assembly **16** is made from nylon with a small amount of Teflon® added (e.g., about 15% by weight) as a friction modifier, although other materials could also be used. In one preferred embodiment, the various bearing shoes **126** provided on the first and second flange members **122** and **124** of the main body portion **82** of the thumb assembly **16** comprise integral portions of the main body portion **82**. Alternatively, the bearing shoes **126** could comprise separate elements that may then be affixed to the first and second flange members **122** and **124**. If so, the various bearing shoes **126** may be fabricated from any of a wide range of materials (e.g., Teflon®) suitable for providing a low friction engagement with the first and second guide rails **116** and **118**.

The foregoing description of the data storage system **20** and related components (e.g., the cartridge picker assembly **10**, thumb assembly **16**, and picker positioning system **34**) is provided in order to better understand one environment in which the improved thumb referencing and guide system **11** according to the present invention may be used. However, as was mentioned above, it should be understood that the improved thumb referencing and guide system **11** may be used in any of a wide range of other types of data storage systems or other similar devices having moveable internal components. Consequently, the present invention should not be regarded as limited to the particular data storage system **20** shown and described herein. Also, since detailed descriptions of the data storage system **20** and related components (e.g., the cartridge picker assembly **10** and the picker positioning system **34**) are not required to understand or practice the thumb referencing invention, the particular data storage

system **20** and related components that may be used in conjunction with the improved thumb referencing and guide system **11** will not be described in greater detail herein.

Referring now primarily to FIGS. **3**, **4**, **5**, and **10**, the improved thumb referencing and guide system **11** may comprise a guide member **12** and a lateral guide surface **14** enabling the cartridge picker assembly **10** to move longitudinally along an X axis between a retracted position **112** (shown in FIG. **9**A) and an extended position **114** (shown in FIG. **9**B). The improved thumb referencing and guide system **11** guides the cartridge picker assembly **10** along a lateral plane formed by an X axis and a Z axis (FIG. **5**), allowing the finger assembly **36** to reliably grasp a data cartridge **22**. In one preferred embodiment, the finger assembly **36** must be positioned adjacent a data cartridge **22** with a maximum side to side offset of about 1.5 mm.

The guide member **12** may comprise a plurality of ribs that extend from the thumb assembly **16**. In one preferred embodiment, the guide member **12** comprises a front guide rib **40** and a rear guide rib **42**. The guide ribs **40** and **42** may be generally rectangular in shape and are attached to the thumb assembly frame **82** so that they extend from the frame **82** to engage the lateral guide surface **14**.

The guide member **12** has a width **50** substantially equal to or just smaller than the distance **66** between the first contact surface **60** and the second contact surface **62**, enabling the guide member **12** to slide longitudinally in the cartridge picker assembly **10** along an X axis (FIG. **5**), but preventing the guide member **12** and the thumb assembly **16** from moving laterally along a Y axis (FIG. **5**).

The lateral guide surface **14** comprises a generally smooth, or otherwise low-friction surface against which the guide member **12** slides as the thumb assembly **16** moves within the cartridge picker assembly **10**. The lateral guide surface **14** may comprise a first contact surface **60** and a second contact surface **62**, placed in spaced-apart, parallel relation to form a channel in which the guide member **12** fits. The first contact surface **60** and the second contact surface **62** are placed apart from each other at a distance **66** which is substantially equal to or just larger than a width **50** of the guide member **12**. This allows the guide member **12** to slide along an X axis but limits side to side movement along a Y axis (FIG. **5**) to allow the finger assembly **36** to reliably grasp an adjacent data cartridge (e.g., **22**). This provides a second benefit of preventing rotation of the thumb assembly **16** around a Z axis which would cause binding of the thumb assembly **16** and misalignment of the finger assembly **36**.

The front guide rib **40** and a rear guide rib **42** have a length **44** and **46**, respectively. The guide ribs **40** and **42** may have any suitable lengths, but in a preferred embodiment lengths **44** and **46** are greater than a distance **66** between the first contact surface **60** and the second contact surface **62**. Along with the lateral alignment benefits during use, this facilitates insertion of the thumb assembly **16** into the cartridge access end **106** of the cartridge picker assembly **10** during the assembly process. As the rear guide rib **42** enters the channel formed by the first and second contact surfaces **60** and **62**, the thumb assembly must be substantially aligned along the X axis before it can be fully inserted. This ensures that the front guide rib **40** will be at or near the proper location to enter the channel, reducing the difficulty of engaging the front guide rib **40** with the lateral guide surface **14**. The guide ribs **40** and **42** may also have curved edges **56** to facilitate assembly and to avoid binding during movement of the thumb assembly **16**.

The guide ribs **40** and **42** may alternatively have lengths **44** and **46** less than the distance **66** between the first and second contact surfaces **60** and **62**, thereby reducing material usage, but the thumb assembly **16** will be able to rotate around a Z axis even after the rear guide rib **42** is engaged with the lateral guide surface **14**, making insertion of the front guide rib **40** more difficult.

Two or more guide members (e.g., **40** and **42**) may provide the necessary control of side to side movement with a minimum of material usage. Alternatively, the guide member **12** may comprise one elongate guide rib having a length greater than the distance **66** between the first and second contact surfaces **60** and **62**.

The first contact surface; **60** of the lateral guide surface **14** may comprise a substantially smooth, elongate member attached to the cartridge picker assembly frame **76**. In one preferred embodiment best seen in FIGS. **6** and **10** the first contact surface **60** comprises the first side wall **78** of the cartridge picker assembly frame **76**, thereby minimizing the tolerance stack by avoiding components and interfaces between the cartridge picker assembly frame **76** and the first contact surface **60**.

The second contact surface **62** may comprise a second substantially smooth, elongate member mounted opposite the first contact surface **60** in parallel, spaced-apart relation. In one preferred embodiment the second contact surface **62** comprises a gear rack **134** having a substantially smooth side **62** and an opposite side **186** having gear teeth **188** for operatively engaging the pinion **136** on the thumb assembly **16**.

The second contact surface **62** may be mounted to the first contact surface **60** with a horizontal bottom surface **190** between them to form a channel for the guide member **12**. The horizontal bottom surface **190** may comprise a portion of the second contact surface **62** or another component. In one preferred embodiment shown in FIG. **10** the horizontal bottom surface **190** comprises the first side wall **78** of the cartridge picker assembly frame **76**.

The second contact surface **62** may be mounted to the first contact surface **60**, or to any components interposed between the first and second contact surfaces **60** and **62**, using any suitable method now known or which may be developed in the future. For example, the second contact surface **62** may be bonded with an adhesive, welded, or molded with the first contact surface **62** as an integral part. In one preferred embodiment, the second contact surface **62** is attached to the first side wall **78** with screws **192**.

The guide member **12** is proportioned to allow slidable engagement with the lateral guide surface **14**. The front and rear guide ribs **40** and **42** preferably have a height **48** that allows the guide ribs **40** and **42** to slide against the lateral guide surface **14** without contacting the bottom surface **190**. As a result, the improved thumb referencing and guide system **11** provides lateral position control without interfering with the vertical position control provided by the first and second guide rails **116** and **118**.

In one preferred embodiment, the guide member **12** has a width **50** between about 2.07 mm and 2.17 mm (2.12 mm preferred), a height **48** between about 5.2 mm and 5.4 mm (5.3 mm preferred), and a length **44** and **46** between about 6 mm and 12 mm (9 mm preferred). The first and second contact surfaces **60** and **62** have a height between about 5.2 mm and 5.5 mm (5.35 mm preferred) and are separated by a distance between about 2.35 mm and 2.45 mm (2.40 mm preferred).

The guide member **12** and the lateral guide surface **14** may be fabricated from any of a wide range of materials, such as polycarbonate plastic or metal. They may be formed

as integral parts of the thumb assembly frame **82** and the picker frame **76**, respectively, or may be fabricated as independent components. The guide member **12** and the lateral guide surface **14** are preferably fabricated of a material providing a low-friction surface. In one preferred embodiment, the guide member **12** is made of nylon having about 30% carbon fiber and about 15% Teflon® and the lateral guide surface **14** is made of polycarbonate having about 12% carbon fiber and about 12% Teflon®.

The improved thumb referencing and guide system **11** provides a reduced tolerance stack by referencing the lateral position of the thumb assembly **16** from only one side **78** of the picker frame **76**, thereby substantially improving the lateral position control of the thumb assembly **16**. The improved lateral position control also decreases the gap between the teeth **188** of the gear rack **134** and the pinion gear **136**, thereby reducing gear backlash and improving accuracy of the longitudinal plunge motion of the thumb assembly **16** in the cartridge picker assembly **10**.

The thumb assembly **16** may be moved between the retracted and extended positions **112** and **114** (FIGS. **9***a* and **9***b*), respectively, by any of a wide range of actuator systems. By way of example, in one preferred embodiment, the thumb assembly **16** may be moved between the retracted and extended positions **112** and **114**, respectively, by a rack and pinion drive assembly of the type shown and described in U.S. patent application Ser. No. 09/045,558, filed Mar. 20, 1988, now U.S. Pat. No. 6,160,786, and entitled "Cartridge engaging assembly with Rack Drive Thumb Actuator System," which is incorporated herein by reference for all that it discloses. Alternatively, other types of thumb actuator systems may be used.

The rack and pinion drive system utilized in one preferred embodiment of the present invention is shown and described in U.S. Pat. No. 6,160,786, referred to above, is best seen in FIG. **6** and may comprise an elongate gear rack **134** that is affixed to the first side member **78** of the picker frame assembly **76**. In one preferred embodiment, the gear rack **134** is attached to the first side member **78** to provide the second contact surface **62** described above as part of the improved thumb referencing and guide system **11**. In this embodiment, the smooth rear side **62** of the gear rack **134** faces the first side member **78**, while the toothed front side of the gear rack **134** faces the second side member so to engage with the rack and pinion drive system

The gear rack **134** may be made from any of a wide range of materials, such as metals or plastics, suitable for the intended application, as will be described in more detail hereinafter.

The main body portion **82** of the thumb assembly **16** may be provided with a pinion gear **136** positioned so that it engages the gear rack **134**. See FIGS. **2**, **3** and **4**. The pinion gear **136** is caused to rotate by a drive system **138** which, in one preferred embodiment, includes a motor **140** and a gear reduction system **142**. The motor **140** may be mounted to the main body portion **82** of the thumb assembly **16** and is operatively associated with the gear reduction system **142** so that the motor **140** rotates the pinion gear **136** to extend and retract the thumb assembly **16**.

The motor **140** may comprise any of a wide range of motors suitable for the intended application. In one preferred embodiment, the motor **140** comprises a permanent magnet D.C. motor, such as model no. RS-385PH, available from Mobuchi Co. of China, although other types may also be used.

The gear reduction system **142** may comprise a conventional gear reduction system utilizing a plurality of spur gears to provide a reduction ratio sufficient to allow the motor **140** to extend and retract the thumb assembly **16** at an appropriate speed and with sufficient force to withdraw and insert the data cartridge **22** into the selected cartridge receiving device. In one preferred embodiment, the gear reduction system **142** provides a reduction ratio of about 11.5:1, although other ratios may be used depending on, for example, the speed and torque characteristics of the particular motor **140** that is selected. The various spur gears comprising the gear reduction system **142** may be made from any convenient material, such as metal or plastic, suitable for the intended application. By way of example, in one preferred embodiment, the various spur gears comprising the gear reduction system **142** are made from brass and stainless steel. Alternatively, the gear reduction system could utilize other types of gears, such as worm gears, to provide the desired reduction.

The thumb assembly **16** may also be provided with any of a wide variety of finger assemblies well-known in the art for engaging data cartridges, such as data cartridge **22**. Accordingly, the present invention should not be regarded as limited to any particular type of finger assembly. By way of example, in one preferred embodiment, the finger assembly **36** may comprise an arm **144** having a hook portion **146**, as best seen in FIG. **3**. Hook portion **146** of arm **144** is configured to engage the notch **148** (FIGS. **9***a* and **9***b*) provided on the data cartridge **22**. The arm **144** is pivotally mounted to the main body **82** of the thumb assembly **16** so that the arm **144** is free to pivot about pivot axis **150**. See FIG. **6**. A spring **156** may be used to bias the arm **144** toward the engaged position shown in FIG. **9***a*. The arm **144** may be provided with a pin **152** (FIG. **6**) which engages a guide track **154** provided on the second side **80** of frame assembly **76** (FIG. **7**). The guide track **154** actuates the arm **144** as the thumb assembly **16** moves back and forth between the retracted position **112** shown in FIG. **9***a* and the extended position **114** shown in FIG. **9***b*. However, since finger and track systems, such as finger assembly **36** and guide track **154**, for engaging cartridges are well-known in the art and could be easily provided by persons having ordinary skill in the art after having become familiar with the teachings of the present invention, the particular finger assembly **36** and guide track **154** used in one preferred embodiment of the present invention will not be described in greater detail herein.

It is contemplated that the inventive concepts herein described may be variously otherwise embodied and it is intended that the appended claims be construed to include alternative embodiments of the invention except insofar as limited by the prior art.

What is claimed is:

1. A cartridge picker assembly, comprising:

a frame having a first side wall and a second side wall positioned in spaced-apart relation and a cartridge access end;

a lateral guide member defining a lateral guide surface, said lateral guide member being attached to the first side wall of said frame so that said lateral guide surface is located a spaced distance from the first side wall of said frame and so that said lateral guide surface is positioned substantially parallel to the first side wall of said frame;

a thumb assembly being adapted to selectively engage and disengage a cartridge and being slidably mounted to the first and second side walls of said frame so that said thumb assembly is capable of moving toward and away from the cartridge access end of said frame; and

a guide member mounted to said thumb assembly, said guide member having a width substantially equal to the spaced distance between said lateral guide surface and the first side wall of said frame, said guide member slidably engaging between said first side wall and said lateral guide surface so that said thumb assembly may move toward and away from the cartridge access end of said frame.

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